Method and electronic acoustic fish attractor

Abstract

We found an approach to the problem of sound attraction of fish from large distances to desirable underwater areas. In case of sound attraction of fish, there are both technical and physical antinomies. To increase distance of influence of attracting sounds, it is required to raise a sound source level. At transmission of sounds with intensity below a hearing threshold of a desirable kind of fish, they will not hear these sounds, and at a critical excess of a hearing threshold, fish startle and immediately swim away. A multi-stage zone transmission of sounds with acoustic feedbacks, in itself, does not ensure necessary conditions. Our invention has overcame these antinomies. Transmissions of sounds carry out under such conditions, that the constant optimum sound threshold field, established on the first zone for a specific species of fish, is conserved on every distance differential under consecutive stages of transmissions of sounds.

Claims

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of a sound attracting fish from large distances to the desirable underwater areas including multi-stage zone transmissions of sounds through a fixed underwater transmitter(s) and active acoustic feedbacks between stages of transmitting sounds

characterized in that said transmissions of sounds carry out under such conditions that the constant optimum sound threshold field, established on first zone for a specific species of fish, is conserved on every distance differential under consecutive stages of transmissions of sounds.

2. The method of a sound attraction of fish in accordance with claim 1 wherein said a constant optimum sound threshold field is established on first zone on the basis of reference data on a hearing threshold of a specific species of fish, transmission loss of intensity of transmitted sounds on first zone and background noise.

3. The method of a sound attraction of fish in accordance with claim 2 wherein said a constant optimum sound threshold field has the confining severely upper bound, which is below of threshold of discomfort, and lower bound, which is a signal-detection threshold.

4. The method of a sound attraction of fish in accordance with claim 3 wherein said the lower bound of a constant optimum sound threshold field is equal to a sum of a reference value of a hearing threshold of a specific species of fish and value of a background noise; and the upper bound is equal to a sum of values of the lower bound and a transmission loss of intensity of a sound on first zone and it is equal to a sound source level on first zone.

5. The method of a sound attraction of fish in accordance with claim 1 wherein said transmissions of sounds through transmitter(s) carry out at sound levels of a source on each subsequent zone, except for first zone, which is a sum of a sound level of a source on first zone and of a transmission loss of intensity of a sound on a previous zone.

6. The method of a sound attraction of fish in accordance with claim 1 wherein said active acoustic feedbacks between zones carry out only through all previous consecutive zone distance differentials right away after a direct sound transmission

7. The method of a sound attraction of fish in accordance with claim 1 wherein said conservation of the constant optimum sound threshold field on every interzone distance differential allows to catch fishes on these zone distance differentials and to set fishing nets on all of them simultaneously.

8. An electronic acoustic fish-attractor comprising a system for providing audio-on-demand (AOD) services, an underwater multi-peak omnidirectional sound projector and power source.

9. The electronic acoustic fish attractor defined in claim 8 wherein said the system for providing the AOD services further comprises the AOD server in which is stored predetermined content; each data item in the data set comprises one or more sections, and the totality of sections constitutes the complete data set; individual data items within the set can be accessed for playback; and active acoustic distributed feedback means in a circuit of a cyclic transmission of sounds.

Description

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to method and system for a sound attraction of the fishes from large distances to a desirable underwater area. For the purpose of attracting and catching fish, the invention may be useful in the amateur, sports and commercial fishing.

[0003] 2. Description of the Prior Art :

[0004] Fish use sound and the acoustical sensor to adapt to their environment. Much work has been done to identify and qualify the marine acoustical environment. Bioacoustics of whales, dolphins and sharks has studied enough deeply. The relationship that fishes have with sound is less understood. Information on bioacoustics of the freshwater fish in most cases is absent. To the best of our knowledge, no one has yet measured the hearing or vibration-detecting capabilities of walleye, bass, muskellunge,etc.

[0005] Hearing capacity of fish is usually expressed as an audiogram, a plot of sensitivity (threshold level in dB SPL) vs. frequency, which is obtained by behavioral or electrophysiological measures of hearing. Fish typically have a U-shaped hearing curve. Sensitivity decreases on either side of a relatively narrow band of frequencies at which hearing is significantly more acute. The decline in sensitivity is generally steepest above the best frequency. Behavioral and neurophysiological hearing curves are generally similar, although behavioral audiograms typically have lower thresholds for peak sensitivities. Most audiograms of fishes indicate a low threshold (higher sensitivity) to sounds within the 20-1000 Hz range. For many fish there are reference data on their hearing thresholds. The amount of such data constantly grows by fast rates. (Richard R. Fay. Fish Hearing Thresholds – Fish Hearing Curves. With 294 original figures, 281 tables).

[0006] Sound is a multi-stage event that requires four components to occur: a source of vibration, a transmitting medium, a receiving detector, and an interpreting nervous system. Sound energy is carried by the oscillation of particles composing a transmitting medium. In the case of fish, the transmitting medium is the water through which they swim.

[0007] Decibels Underwater Are Not The Same As Decibels In Air! "Underwater 160 dB" is equivalent to 98 dB in-air. A level of 122 dB in-water is equivalent to 60 dB in-air. This is the level human would hear when having a normal conversation (Cornel Lab., Bioacoustics Research Program).

[0008] The fishes can swim on two speeds: with a burst swimming speed (a maximum swimming speed which can be maintained for less than a minute only) and with a sustained speed (swimming at this speed for a prolonged time). The FishBASE Tables contain information at sustained and burst speeds for different species of fish. The information was extracted from over 50 references such as Bainbridge (1958, 1960), and Welb (1971) and compilations such as Sambilay (1990). The Speed Table consists of the following fields: Length: This field pertains to the length of fish in centimeters as stated SL (Standard Length); FL (Fork Length); TL (Total Length); BL (for the term "body length", stated in the publication but without the type of length measurement being indicated).

[0009] U.S. Pat. No. 4,922,468 discloses method and apparatus for controlling the population of marine and aquatic creatures in limited areas. Also U.S. Pat. No. 5,282,178 discloses method and apparatus for attracting fish to a selected location.

SUMMARY OF THE INVENTION

[0010] In case of sound attraction of fish, there are both technical and physical antinomies. To increase distance of influence of attracting sounds, it is required to raise

a source broadcasting level. At transmission of sounds with intensity below a hearing threshold of a desirable kind of fish, the last will not hear these sounds, and at acritical excess of a hearing threshold, the fishes will startle and immediately swim away. The multi-stage zone transmission of sounds with acoustic feedbacks , in itself, does not provide necessary conditions.

[0011] Our invention has overcame these antinomies. We utilize the physical effect of logarithmic dependence of transmission loss of sound intensity from distance, described by Richardson (1995):

[0012] SIL = SL – TL, where SIL is sound intensity level; SL is source level and TL is transmission loss. $TL = TL_g + TL_\alpha$, where $TL_g = 20 \log r$ and $TL_\alpha = \alpha r$, where r is a distance of spreading a sound and α is the attenuation coefficient and a function of frequency.

[0013] Establishment of an optimum sound threshold field for a specific species of fish is the most difficult task. The hearing thresholds of fish are defined in laboratory conditions. In field conditions, where there is a background noise, the threshold sensitivity shifts. The signal-detection threshold is more of a reference value of a hearing threshold. An each species of fish has its optimum sound threshold field. The upper bound of this field (UB) should be lower of a threshold of discomfort, at which fish are startle and immediately are swimming away. The lower bound of this field (LB) is a signal-detection threshold, below which fish can not hear this signal.

[0014] Hence, we can accept, that the value of intensity of a sound on the lower bound of an optimum sound threshold field is equal to reference value of a hearing threshold (HT) plus an additive correction on background noise (AC), i.e.:

$$LB = HT + AC \qquad (1).$$

The upper bound of an optimum sound threshold field (UB) then will include value of the lower bound of this field plus loss of intensity of a sound (TL) on distance to a sound source, i.e.:

$$UB = LB + TL \qquad (2),$$

or

$$UB = HT + AC + TL \qquad (3).$$

The difference threshold (D) in a optimum threshold sound field, subject to (1) and (2), will be equal:

$$D = TL, \qquad (4).$$

[0015] Approximately, neglecting by the attenuation coefficient α, at distances 3, 10, 30, 100, 300, 1000, 3170, 10000 m from a sound source, losses of intensity of a sound are accordingly equal to 10, 20, 30, 40, 50, 60, 70, 80 dB re: 1μPa. At distances 5, 25, 126, 630, 3170, 16000 m from a sound source, losses of intensity of a sound are accordingly equal to 14, 28, 42, 56, 70, 84 dB re: 1μPa. In both cases, all subsequent losses of

intensity of a sound are multiple to loss of intensity of a sound on the first zone: 3m or 5m. Thus, **in adduced series of losses of intensity of sounds, the loss of intensity of a sound on first zone is by the least common multiple (LCM).** On the specified distances from a sound source there is a constant value of a gain of losses of intensity of a sound on each subsequent zone. In the first case, it is equal 10 dB, and in the second case it is equal 14 dB.

[0016] It is very important, constant optimum sound threshold field, established on the first zone, is conserved on each distance differential of the subsequent adjacent zone, i.e., if: UB $=I_1$, this intensity of sound also is a source sound level on the first zone, and LB $= I'_1$, then: $\mathbf{I_1 - I'_1 = D_1 = const,}$ (5).

[0017] On each subsequent zone, starting with the second zone, the sound source level is equal to the sum of values of a source sound level (SL) on the first zone and of transmission losses of intensity of a sound on each previous zone.

[0018] These remarkable regularities of the differential phase shift to the right of a constant optimum sound threshold field, but each time on larger distance, was used by us for elaboration of our system of transmitting sounds on large distances with the purpose of attracting fish to an any desirable location.

[0019] The attraction fish to the first zone from the other zones, i.e. active acoustic feedbacks, carry out only through all previous consecutive zone distance differentials right away after the direct sound transmission on any zone.

[0020] The active acoustic feedbacks, with the exception of the first zone, comprise time periods of broadcasting sounds on every interzone distance differential; these time periods are determined as function of length of a corresponding zone distance differential and speed of swimming of a specific species of fish.

[0021] At the stationary fixed underwater arrangement of a transmitter of attracting sounds, the fishing is possible not only in the first zone, but also on all interzonal distance differentials. At commercial fishery, fishing nets can be simultaneously setted in all stated places.

[0022] Typical diagram representations with reference to Atlantic Salmon, as example, is considered in the section: " Detailed Description of the Invention".

[0023] According to a further aspect of the invention, there is provided an acoustic generating system by use of a method of sound attraction of fish as hereinbefore described.

[0024] An electronic acoustic fist attractor comprising:

[0025] A system for providing audio-on-demand (AOD) services, an underwater multi-peak omnidirectional sound projector and power source.

[0026] The system for providing the AOD services further comprises: the AOD server in which is stored predetermined content; each data item in the data set comprises one or more sections, and the totality of sections constitutes the complete data set; individual data items within the set can be accessed for playback; and active acoustic distributed feedback means in a circuit of a cyclic transmission of sounds.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The invention will now be described by way of an example only and with reference to FIG. 1 to 3 of the accompanying drawings, in which:

[0028] FIG. 1 is a diagram representation of an arrangement for transmitting sounds in operation in water in accordance with the invention, (in general form);

[0029] FIG. 2 is a diagram representation of an arrangement for transmitting sounds in operation in water in accordance with the invention, for example, for attracting Atlantic Salmon with a hearing threshold equal to 89 dB re: 1μPa@1m at length of the first zone equal 3m; and

[0030] FIG. 3 is a diagram representation of an arrangement for transmitting sounds in operation in water in accordance with the invention, for example, for attracting Atlantic Salmon with a hearing threshold equal to 89 dB re: 1μPa@1m at length of the first zone equal 5m.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0031] Turning first to FIG. 1, therein diagrammatically illustrate in a general form is mathematical model of our method embodying the present invention and depicts multi-zone chain transmissions of sounds through transmitter and active acoustic feedbacks between zones.

[0032] All intensities of a sound are calculated concerning the fixed stationary placement of a source of a sound. The source levels of sound are: $SL_1 < SL_2 < SL_3 < \ldots < SL_{n-2} < SL_{n-1} < SL_n$.

[0033] $SL_1 = UB = I_1$ and $LB = I_1'$ (see equations (1) and (2)) are correspondingly an upper bound and a lower bound of an optimum threshold sound field for a specific species of fish on the first zone with length d_1. By equation (4), the difference threshold on the first zone (D_1) is equal to a transmission loss of intensity of a sound on first zone (TL_1).The transmission loss is a function of distance on which a sound is transmitted. For first zone by such distance is its length d_1. As our model of transmission of sounds provides conservation of the difference threshold established on first zone, on all Interzone distance differentials, length of first zone is determinant for all sequence of multi-stage zone transmission of sounds.

[0034] There are messages that fish are attracted by a sound and are successfully caught from distances from 3 up to 5 meters. It is considered, that on such distance a background noise does not exceed 3 dB. Transmission losses of intensity on distances 3 and 5 m are correspondingly 10 and 14 dB re: 1μPa@1m. Then, subject to equations (1), (3) and (4) we have:

at length of the first zone equal to 3m:

$$LB = HT + 3, \quad (6)$$

$$UB = HT + 3 + 10 = HT + 13, \quad (7)$$

$$D = 10\text{ dB}, \quad (8)$$

at length of the first zone equal to 5m:

$$LB = HT + 3, \quad \text{The same as (6)}$$

$$UB = HT + 3 + 14 = HT + 17, \quad (9)$$

$$D = 14\text{ dB}. \quad (10)$$

[0035] On each subsequent zone, starting with the second zone, we have the such sound levels: $SL_2 = SL_1 + TL_1$; $SL_3 = SL_1 + TL_2$; $SL_4 = SL_1 + TL_3$;...; $SL_{n-2} = SL_1 + TL_{n-3}$; $SL_{n-1} = SL_1 + TL_{n-2}$; $SL_n = SL_1 + TL_{n-1}$. (11)

[0036] FIGURES 2 and 3, therein diagrammatically illustrate the work of our method, with reference to Atlantic Salmon with a hearing threshold equal to 89 dB re: 1μPa@1m, on two conditions: at length of first zone equal 3m and 5m.

[0037] **Length of the first zone is equal 3m.** By the equations (6), (7), (8), (11) accordingly we have: LB = 92 dB, UB = 102 dB, D = 10 dB. SL_1 = UB = 102 dB.

[0038] **Second Zone**. Functionally it is adjacent with the first zone. The level of a source sound SL_2 = 112 dB. The full length of the second zone d_2 = 10m. In the portion left of this zone, equal to the length of the first zone (3m), are such intensities of transmitted sounds, that fish startle and immediately swim away. But, in the portion ($d_2 - d_1$) = 7m WE have at the beginning an increment and at its end accordingly values of a sound intensity are equal 102 dB and 92 dB. The same as on the first zone, but with an increase of distance.

[0039] **Third Zone.** Functionally it is adjacent with the second zone. The level of a source sound SL_3 = 122 dB. The full length of the third zone d_3 = 30m. In the portion left of this zone, equal to the full length of the second zone (10m), are such intensities of transmitted sounds, that fish startle and immediately swim away. But, in the portion ($d_3 - d_2$) = 20m we have at the beginning an increment and its end accordingly values of a

sound intensity are equal 102 dB and 92 dB. The same as on the first zone, but with a consequent increase of distance.

[0040] **Forth Zone.** Functionally it is adjacent with the third zone. The level of a source sound SL_4 = 132 dB. The full length of the forth zone d_4 = 100m. In the portion left of this zone, equal to the full length of the third zone (30m), are such intensities of transmitted sounds, that fish startle and immediately swim away. But, in the portion $(d_4 - d_3)$ = 70m we have at the beginning an increment and its end accordingly values of a sound intensity are equal 102 dB and 92 dB. The same as on the first zone, but with the further increase of distance.

[0041] **Fifth Zone.** Functionally it is adjacent with the forth zone. The level of a source sound SL_5 = 142 dB. The full length of the fifth zone d_5 = 300m. In the portion left of this zone, equal to the full length of the forth zone (100m), are such intensities of transmitted sounds, that fish startle and immediately swim away. But, in the portion $(d_5 - d_4)$ =200m we have at the beginning at increment and its end accordingly values of a sound intensity are equal 102 dB and 92 dB. The same as on the first zone, but with the further increase of distance.

[0042] **Sixth Zone.** Functionally it is adjacent with the fifth zone. The level of a source sound SL_6 = 152 dB. The full length of the sixth zone d_6 = 1000m. In its portion $(d_6 - d_5)$ = 700 we have at the beginning at increment and its end accordingly values of a sound intensity are equal 102 dB and 92 dB. The same as on the first zone, but with the further increase of distance.

[[0043] **Seventh and Eight Zones** with source sound levels accordingly 162 dB and 172 dB give to us distances 3170m and 10000m.

[0044] FIG. 3 depicts mode of operations of a system **when length of first zone is equal 5m.**

[0045] **First Zone.** By the equations (6), (9), (10), (11) соответственно we have имеем: LB = 92 dB, UB = 106 dB, D = TL = 14 dB, SL_1 = UB = 106 dB.

[0046] **Second Zone.** The level of a source sound SL_2 = 120 dB. The full length of the second zone d_2 = 25m. In the portion left of this zone, equal to the length of the first zone (5m), are such intensities of transmitted sounds, that fish startle and immediately swim away. But, in the portion $(d_2 - d_1)$ = 20m we have at the beginning an increment and at its end accordingly values of a sound intensity are equal 106 dB and 92 dB. The same as on the first zone, but with an increase of distance.

[0047] **Third Zone.** The level of a source sound SL_3 = 134 dB. The full length of the third zone d_3 = 126m. In its portion $(d_3 - d_2)$ = 101m we have at the beginning an increment and at its end accordingly values of a sound intensity are equal 106 dB and 92 dB. The same as on the first zone, but with a subsequent increase of distance.

[0048] **Forth Zone.** The level of a source sound SL_4 = 148 dB. The full length of the forth zone d_4 = 630m. In its portion ($d_4 - d_3$) = 504m we have at the beginning an increment and at its end accordingly values of a sound intensity are equal 106 dB and 92 dB. The same as on the first zone, but with the further increase of distance.

[0049] **Fifth Zone.** The level of a source sound SL_5 = 162 dB. The full length of the fifth zone d_5 = 3170m. In its portion ($d_5 - d_4$) = 2540m we have on bounds of the distance differential accordingly values of a sound intensity are equal 106 dB and 92 dB. The same as on the first zone, but with the further increase of distance.

[0050] **Sixth Zone.** The level of a source sound SL_6 = 176 dB. The full length of the sixth zone d_6 = 16000m. In its portion ($d_6 - d_5$) = 12830m we have on bounds of the distance differential and its end accordingly values of a sound intensity are equal 106 dB and 92 dB. The same as on the first zone, but with the further increase distance.

[00551] How the time intervals of each step are defined? The speed of sound in water is approximately 1,500 m/s. An attracting signal will reach fish, located on distance 1,000 m, for 0.67 seconds, and fish, located on distance 100 m, practically instantly. The fish will start swimming, obviously, with a burst swimming speed. Distance is large. One minute has passed. Then the fish passes to a mode of a sustained speed. A significant interval of a modulation at every step of multi-step transmission a sound is calculated elementarily: .tau.=d:v, where .tau. is necessary time of broadcasting, (s); d is length of zone,(m), and v is swimming speed of fish, (m/s).

[0052] Atlantic Salmon: 100,0 cm TL, a burst speed is 1.0 m/s and a sustained speed is 0.11 m/s. Now, there are all data to calculate necessary time of broadcasting attracting signal for each step of the appropriate mathematical model of multi-step transmission of sounds.

[0053] Step I: Site of Sound Source--distance 5 m. Time limit is not established.

[0054] Step II: Distance differential is equal: (25 m-5 m)= 20 m. The time interval is equal: 20 m:1.0 m/s= 20.0 s.

[0055] Step III: Distance differential is equal: (126 m - 25 m)= 101 m. The time interval is equal to time of swimming with a burst speed (during 60 s) plus time of swimming with a sustained speed: 101 m :1.0 m/s= 101,0 s.
a) 1.0 m/s x 60.0 s = 60 m;
b) (101 m – 60 m) : 0.11 m/s = 373 s.
The total time is equal: Σ tau = 60 s + 373 s = 433 s = 7 min 13 s,

[0056] Step IY: Distance differential is equal: (630 m- 126 m)= 504 m. The time interval is equal to time of swimming with a burst speed (during 60 s) plus time of swimming with a sustained speed:
a) 1.0 m/s.times.60.0 s=60 m;
b) (504 m – 60 m): 0.11 m/s= 4036 s = 67 min 16 s;

The total time on step IY is equal: .SIGMA..tau.= 60 s + 4036 s = 4096 s = 68 min 16 s.

[0057] Step Y: Distance differential is equal: (3170 m - 630 m) = 2540 m. The time interval is equal to time of swimming with a burst speed (during 60s) plus time of swimming with a sustained speed:
a) 1.0 m/s.times.60.0 s=60 m;
b) (2540 m - 60 m): 0.11 m/s= 22545 s;
The total time on step Y is equal: .SIGMA..tau.= 60.0 s+22545 s= 22605 s = 377 min,

[0058] Step YI: Distance differential is equal: (16000 m – 3170 m) = 12830 m. The time Interval is equal:
a) 1.0 m/s.times.60.0 s = 60 m;
b) (12830 m – 60 m) : 0.11 m/s = 116091 s;
The total time on step YI is equal: SIGMA tau = 60.0 s + 116091 s = 116151 s = 1936 min.

[0059] Total time on steps II-Y is equal: .SIGMA..tau.= 20 s + 433 s + 4096 s + 22545 s + 116151 s = 143245 s = 2387 min ≈ 40 hours.

[0060] For example, the following sequence is possible in steps for attracting Atlantic Salmon:

[0061] "Step I" is turned on for 2-3 minutes. If a bite began, to continue to fish in this mode. If a bite is absent, then:

[0062] "Step II" is turned on. "Step II" will be switched over automatically on "Step I" after the expiration 20 seconds. If a bite began, to continue to fish in this mode. If a bite is absent, then

[0063] "Step III" is turned on. "Step III" will be switched over automatically on "Step II" after the expiration 433 seconds, and "Step II" will be switched over automatically on "Step I" after the expiration 20 seconds. If a bite began, to continue to fish in this mode.

If a bite is absent, then

[0064] "Step IY" is turned on. "Step IY" will be switched over automatically on "Step III" after the expiration 514 seconds; "Step III" will be switched over automatically on "Step II" after the expiration 34 seconds, and "Step II" will be switched over automatically on "Step I" after the expiration 11 seconds. If a bite began, to continue to fish in this mode. If a bite is absent, then:

[0065] Similarly Steps Y and YI are turned on and are switched over automatically.

[0066] Multiple recurrences of turns-on are possible on any step of transmission of a sound.

[0067] Time intervals for other kinds of fishes are calculated analogously.

[0068] Critical analysis of two modes of operations of system at lengths of first zone **3m** and **5m**, on an example of Atlantic Salmon, has shown:
a) Excess of a hearing threshold of Atlantic Salmon in the first case constitutes about 15 per cent and in the second case about 19 per cent;
b) In the first case, the system works flexibly, it ensures smooth transitions between consecutive stages of transmission of sounds. The system can be used at engineering electronic acoustical attractors of fishes as at amateur fishing, and commercial fishing;
c) In the second case, the system can be used at amateur fishing with comprising only first, second and third stages of transmissions of sounds.

[0069] Although preferred embodiments have been describe herein in detail, it is understood by those skilled in the art that variations may be made thereto without departing from the scope of the invention or the spirit of the appended claims.